2016 Design Training Expo

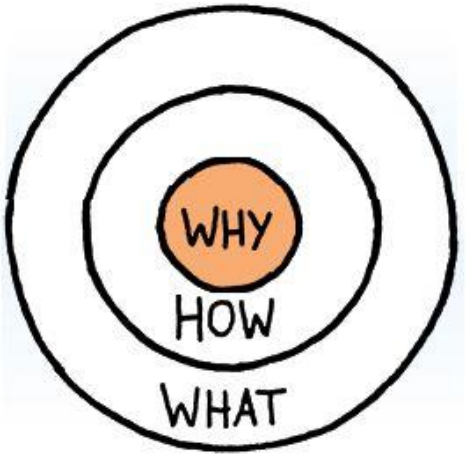
3D Radar Tomography

Gary R. Roche, PSM (FDOT)
Carlo Pilia (Cardno)

3D Radar Tomography, SUE and FDOT Design Projects:

3D Corridor Modeling (*WHY*):

- To represent existing utilities in 3-Dimensions throughout the project limits



3D Utility Investigation (*HOW*):

- Processes to gather continuous 3D utility information

Advanced Geophysics (*WHAT*):

- Synchronized array of multi-frequency GPR antennas obtaining Radar Tomography Data (RT 3D Imagery)

3D Radar Tomography:

- **Assists with the determination of horizontal and vertical location of existing underground utilities and features**

PROS:	CONS:
Continuous Imagery	Extensive Data Processing
Calibration of Data	Highly Skilled User
Detects Utilities and Other Features	Geophysical Limits

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Detects Utilities and Other Features	Geophysical Limits

Geophysical Limits:

- **Not all utilities will be detected**
- **Utility type will not be identified**

Solution:

- **Full conventional utility investigation AND Radar Tomography**

Result:

- **3D Utility information to use for 3D Design/Corridor Modeling**

Statewide Consultant Support for Radar Tomography, a Subsurface Utility Engineering (SUE) Mapping Technology

TWO1: SR46 (Wekiva 7A) / District 5

TWO2: SR60 (Kennedy Blvd) / District 7

TWO3: Amtrak Hollywood Station / District 4

TWO4: SR189 / District 3

TWO5: SR600 / District 5

TWO6: SR5 / District 5

Process:

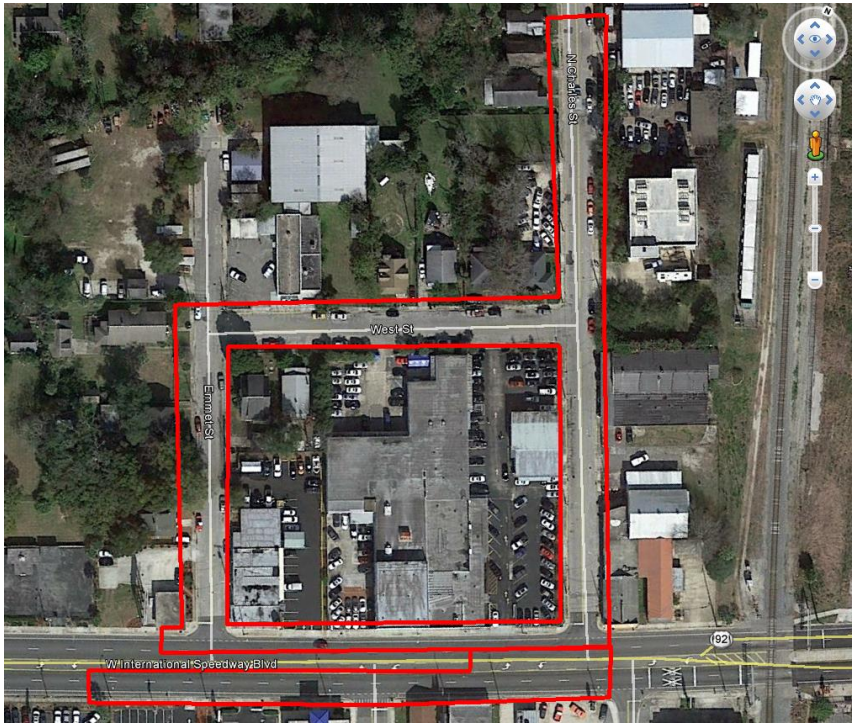
- Obtain Utility Records
- Recover/Establish Project Horizontal and Vertical Control
- Scan Areas and Record Raw RT Data
- Complete Conventional Designating with Electronic Depth Estimates and visual inspection of accessible points
- Complete Locating to assist in calibrating RT
- Survey
- Process and Prepare Deliverables

TWO5: SR600 from Emmet St. to Charles St., Volusia County (FPID: 436855-1 / Drainage Project)

Design Consultant: DRMP;
SUE Provider: Cardno

RT Objective:
Identify the less congested area for new drainage pipes

Scope:
Scan 2.32ac, 34 Test Holes (THs), provide UTEX.dgn 2D/3D



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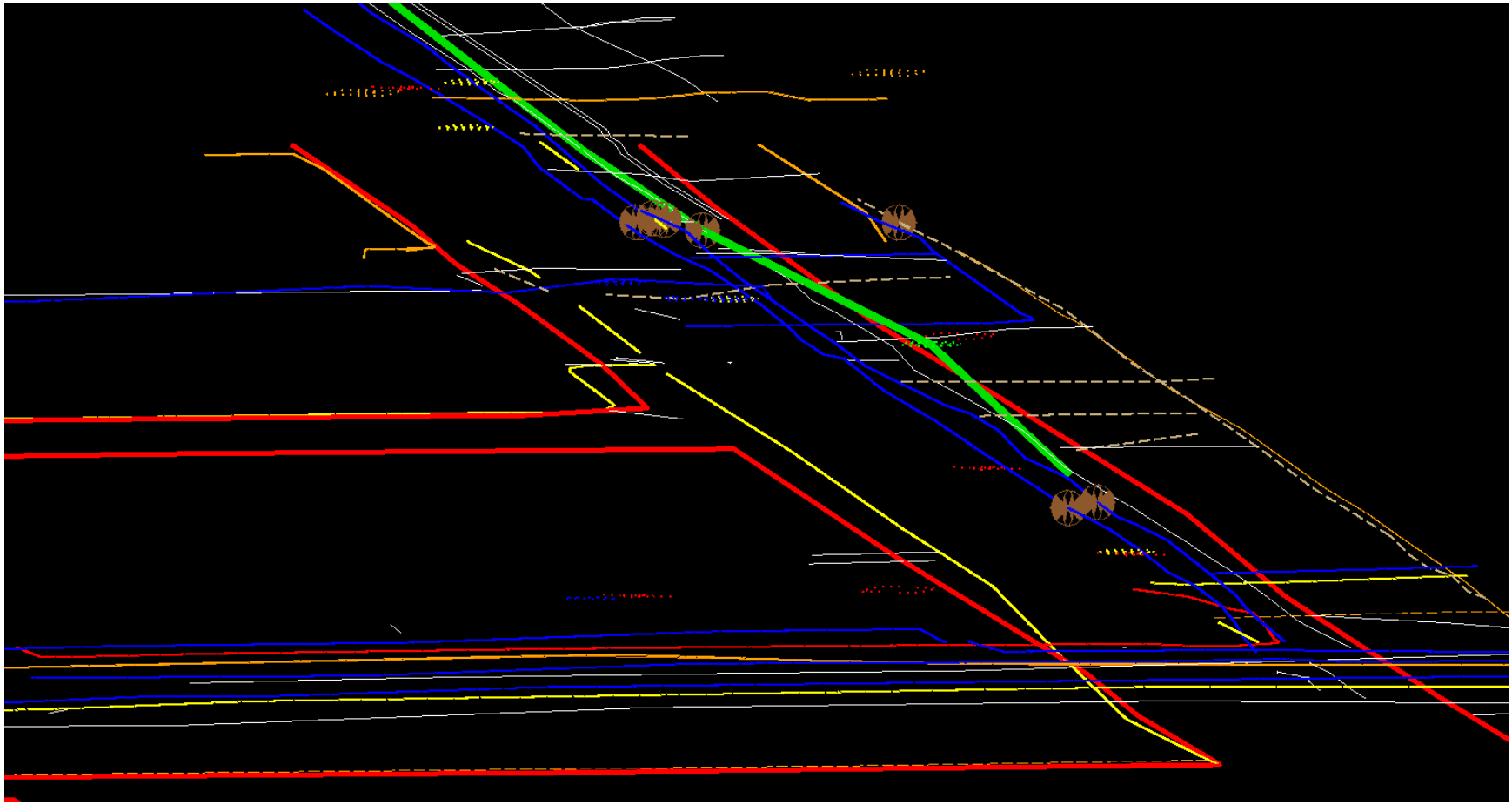
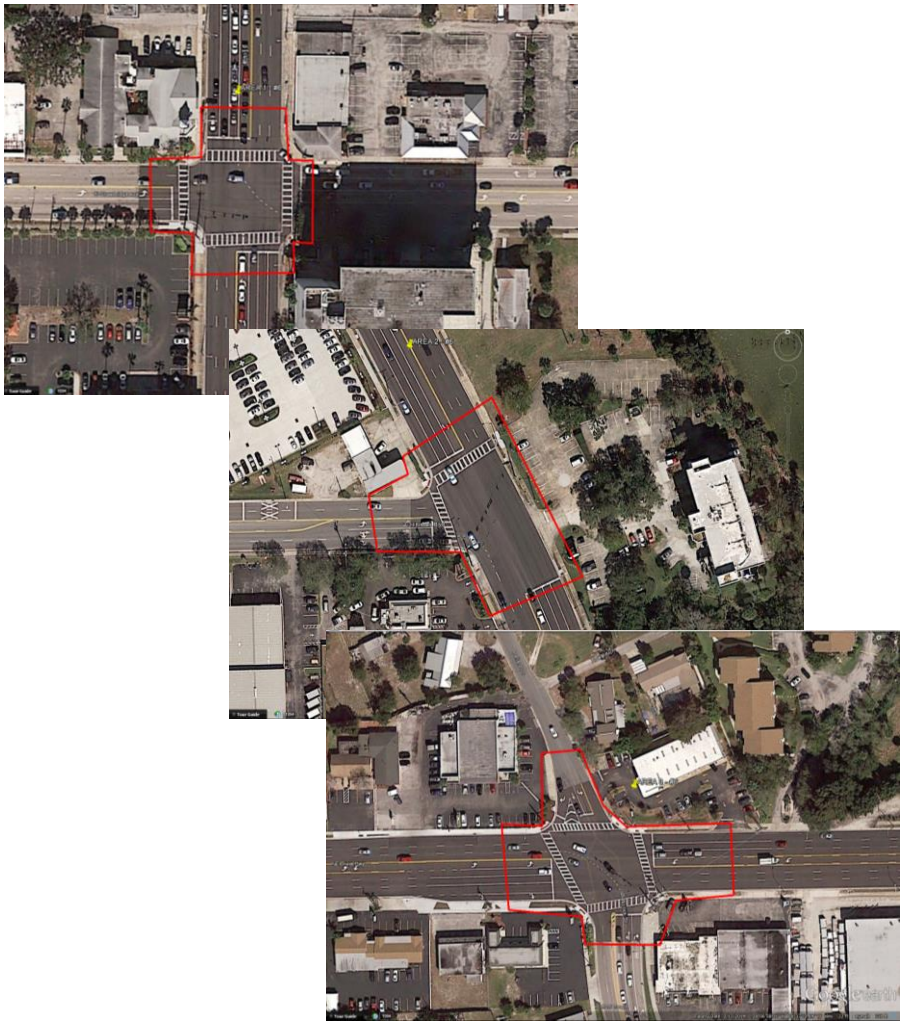


TWO6: SR5/US1 at Ballard, Hibiscus and US192 (FPID: 4235652-1 / Intersection Improvements)

Design Consultant: DRMP;
SUE Provider: Cardno

RT Objective:
Obtain 3D utility information within limits

Scope:
Scan 1.79ac, 24THs provide UTEX.dgn 2D/3D. Clear mast arms foundations



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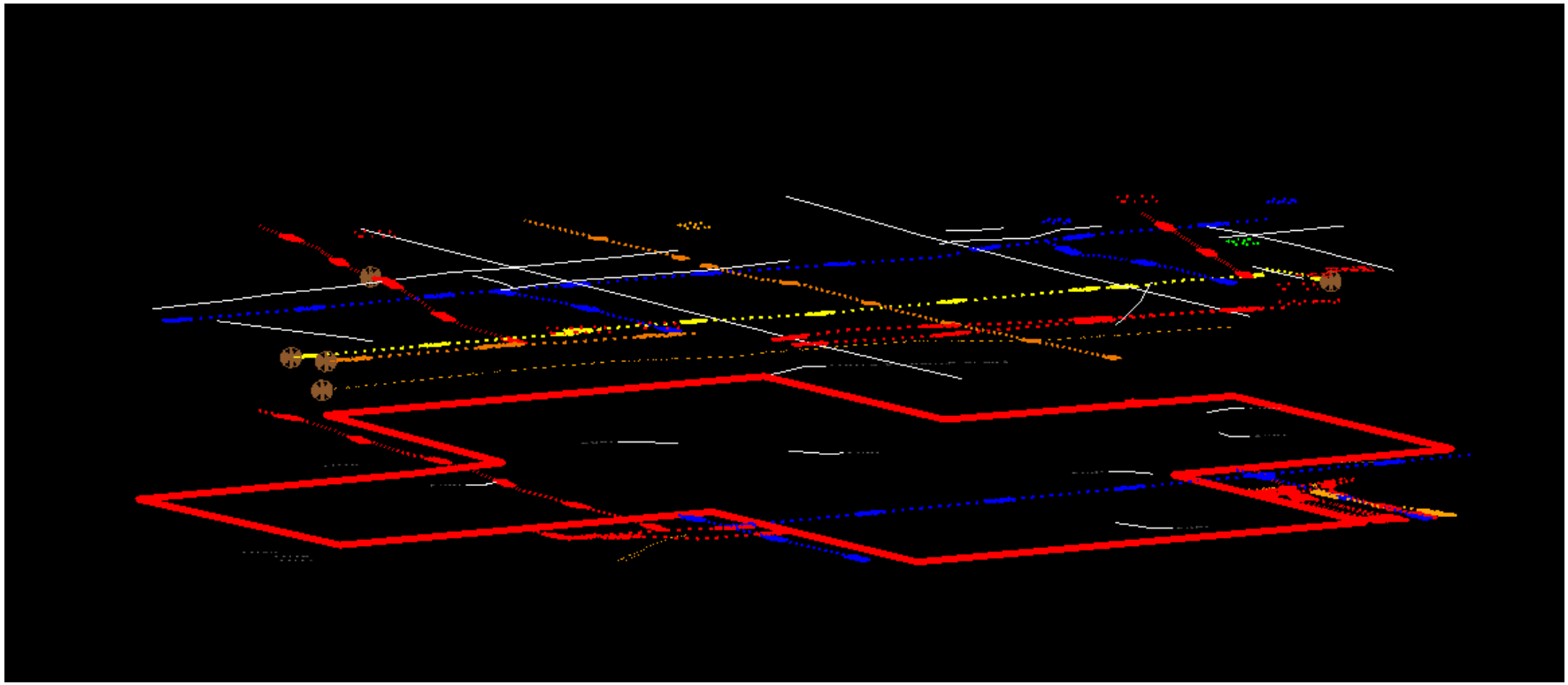
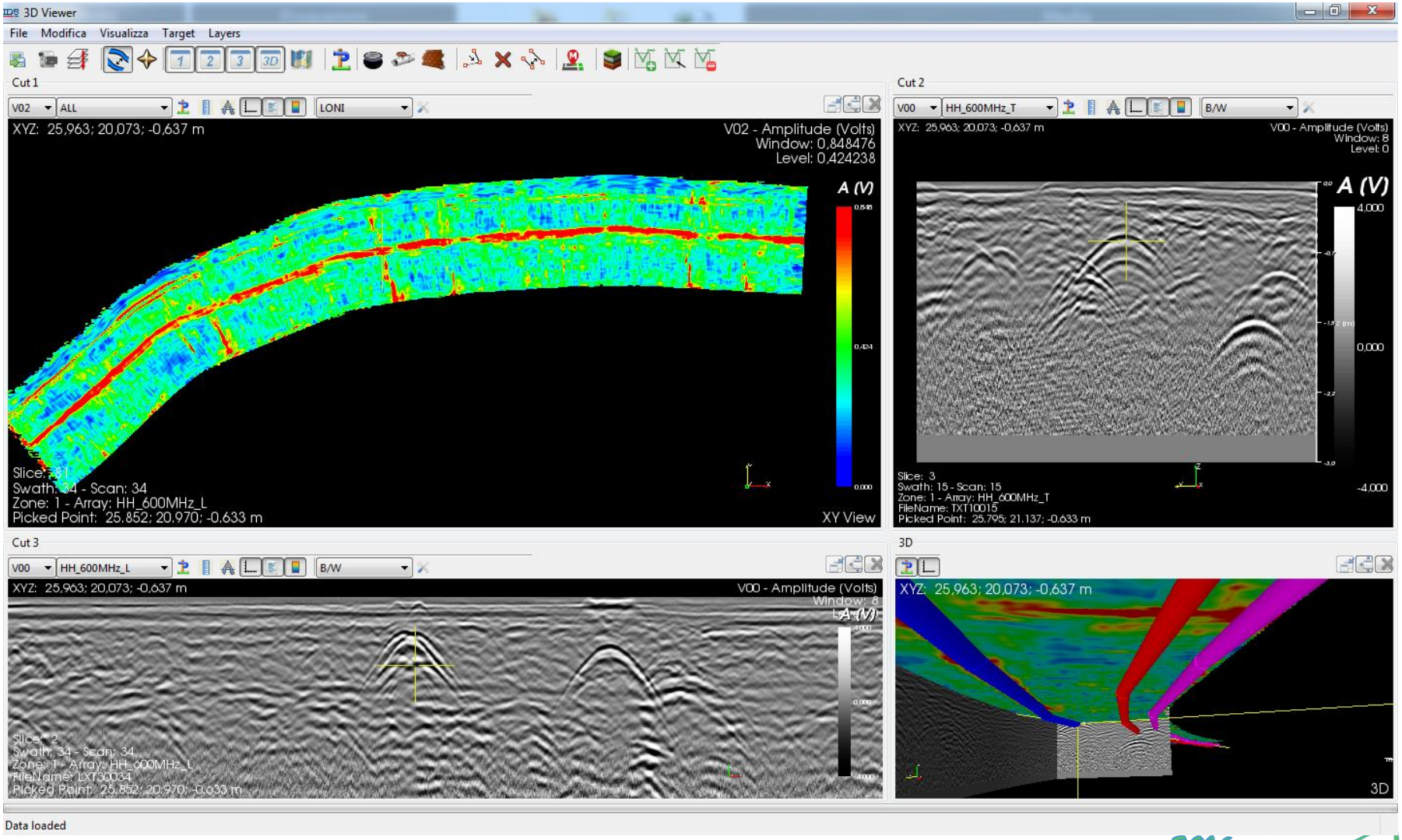


How do we obtain estimated “Z” information?

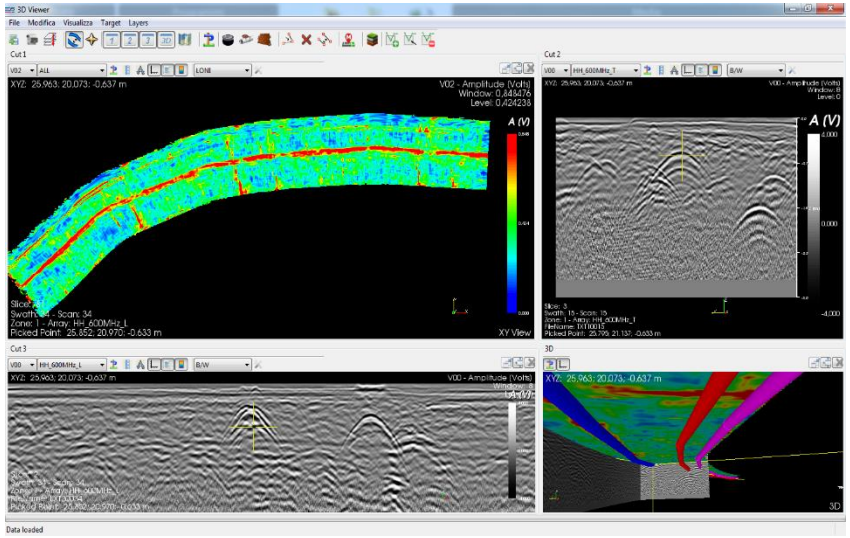
- Dedicated field data collection
- Advanced geophysics / data interpretation

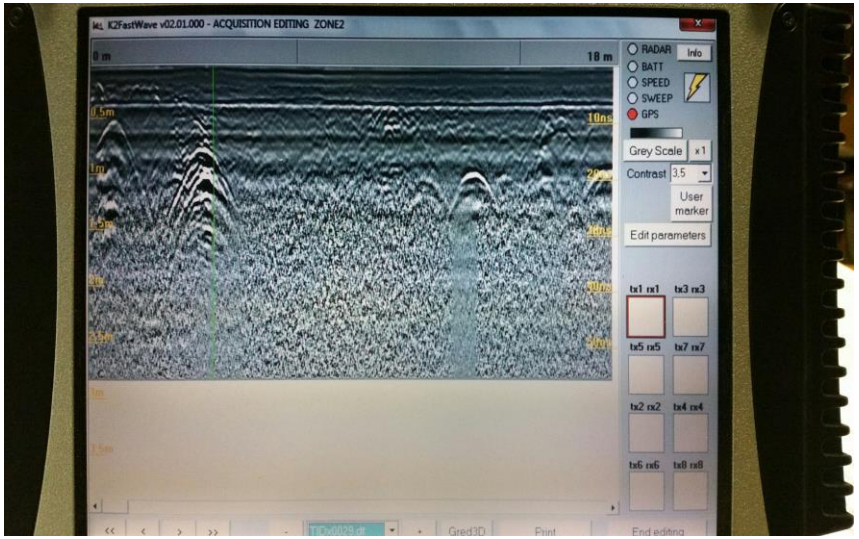
3D Radar Tomography

3D Radar Tomography

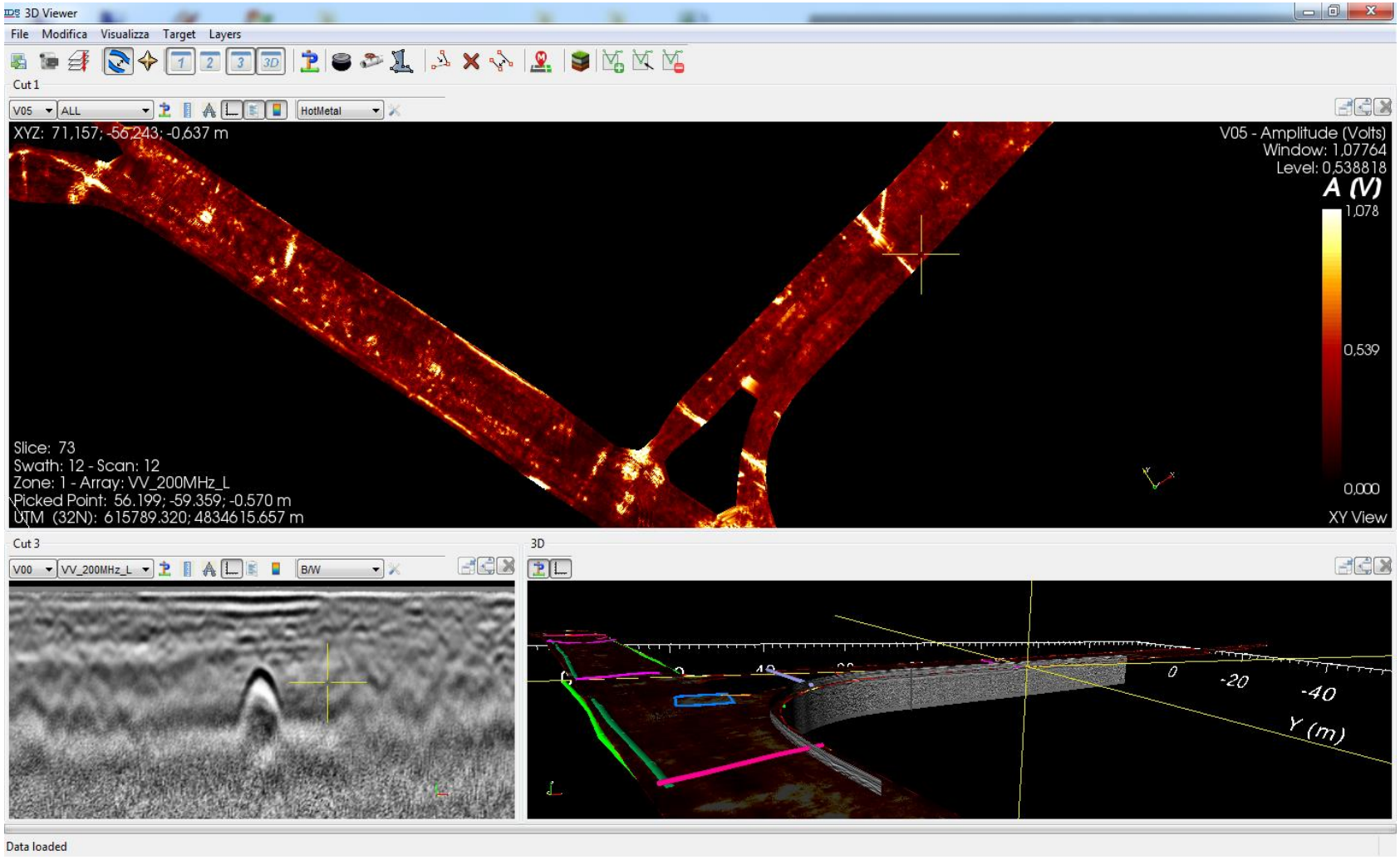


3D Radar Tomography vs. Real Time GPR





Depth Information from Different Data Sets



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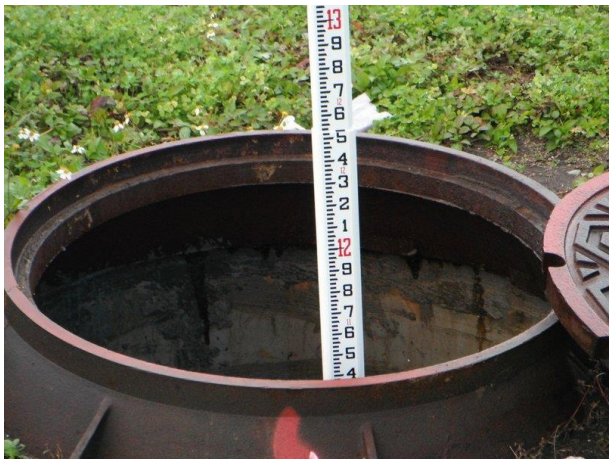
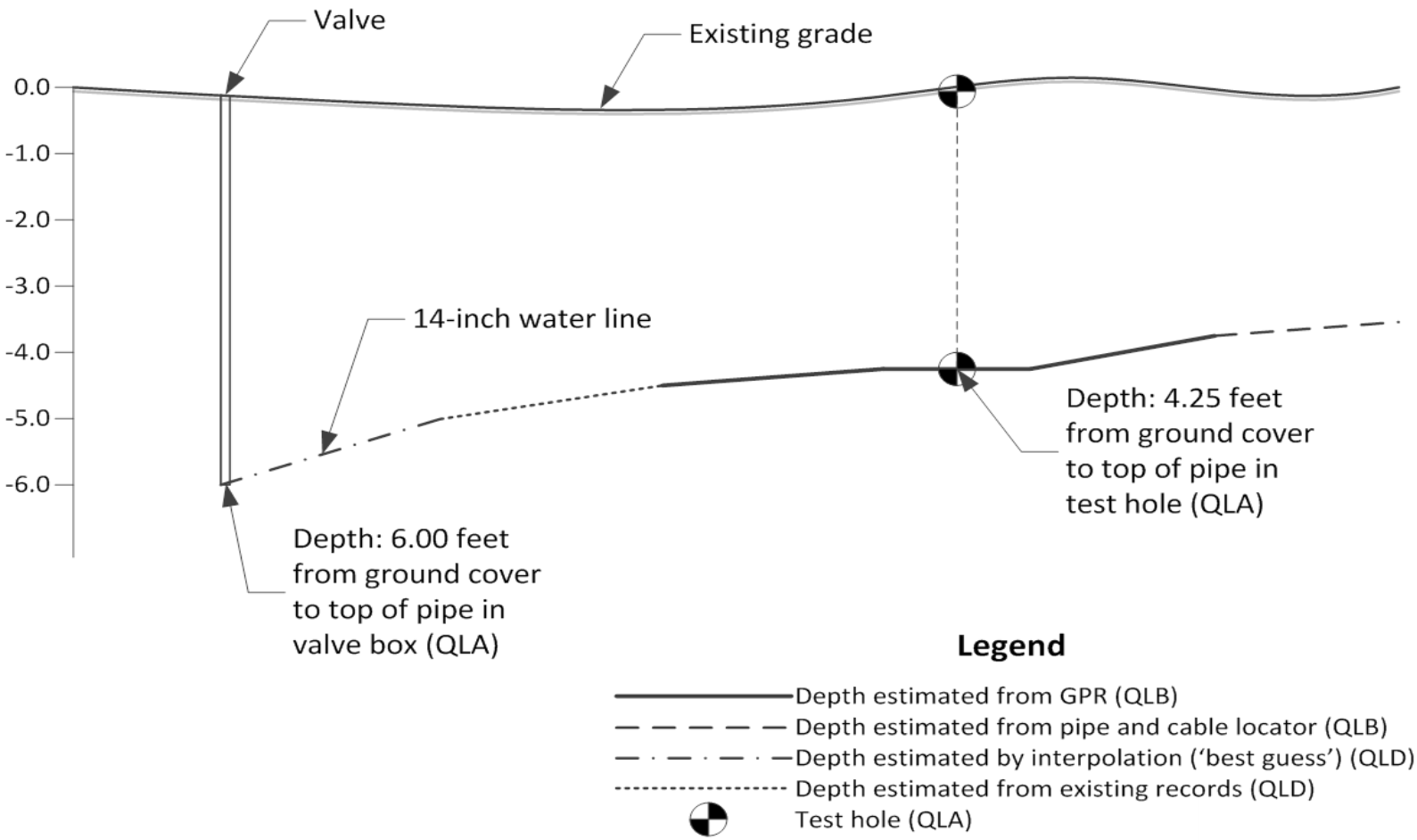


Vertical Data Management

Compare and analyze Z from different data sets



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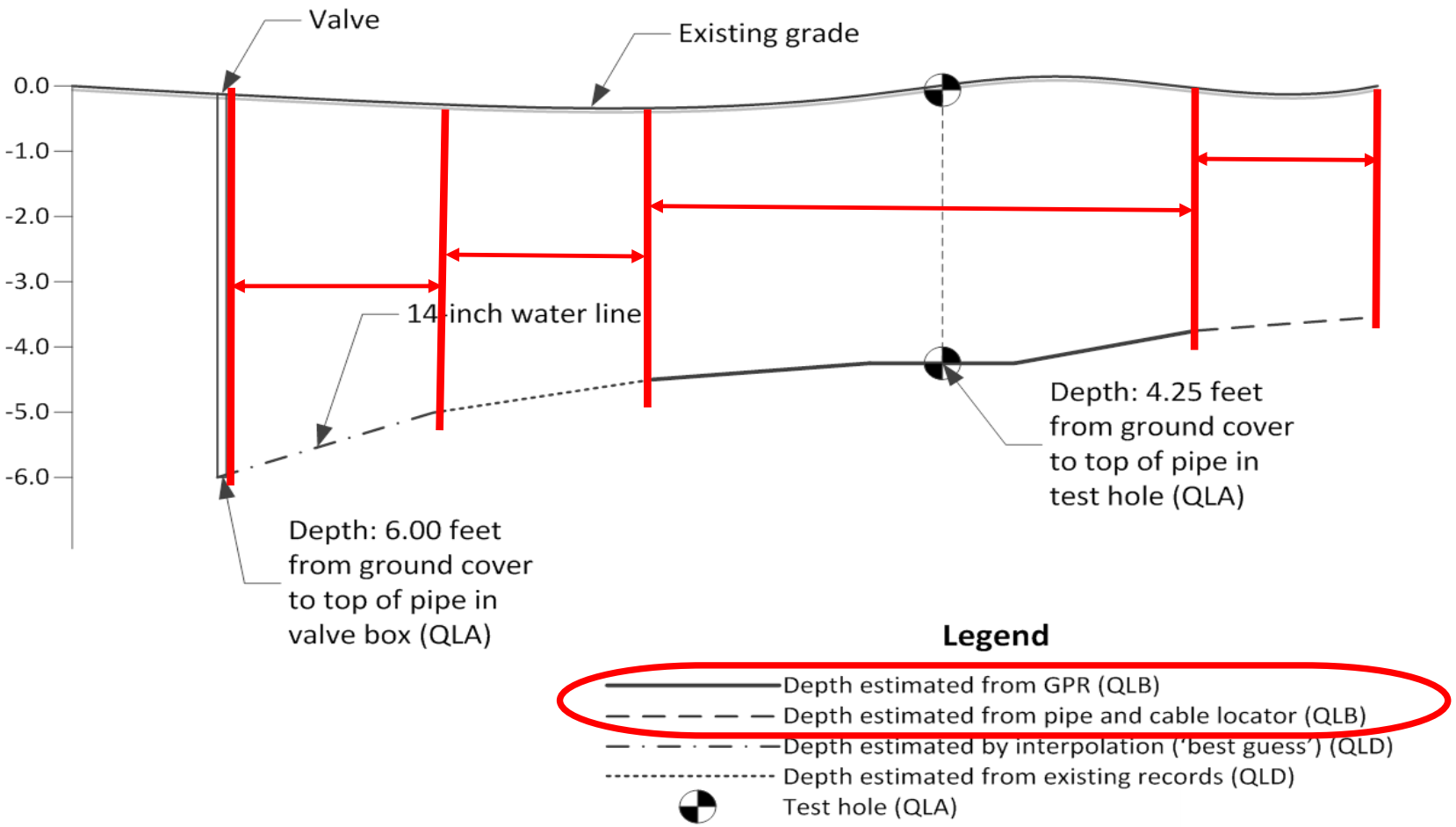


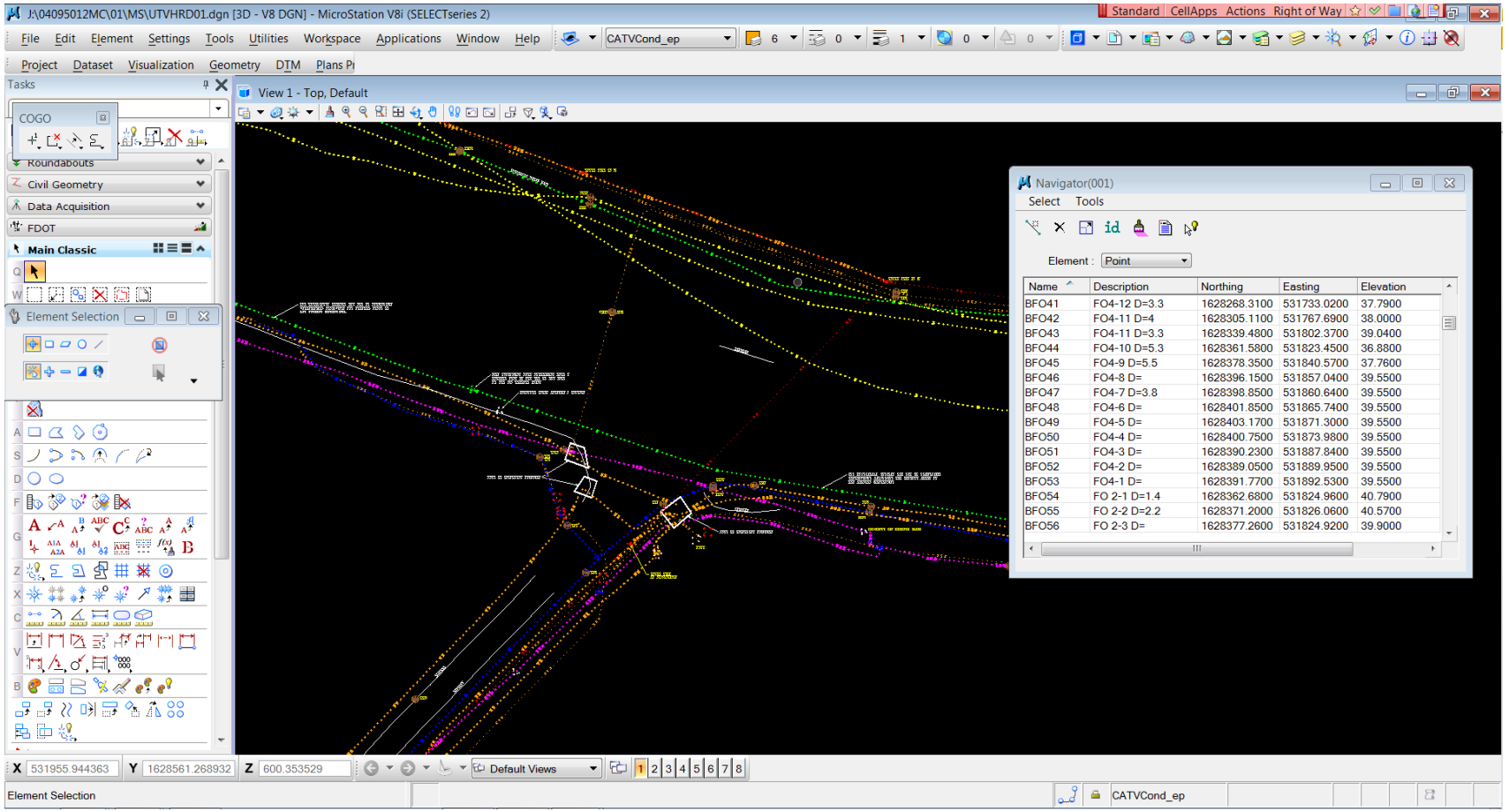
Vertical Data Management

Compare and analyze Z from different data sets

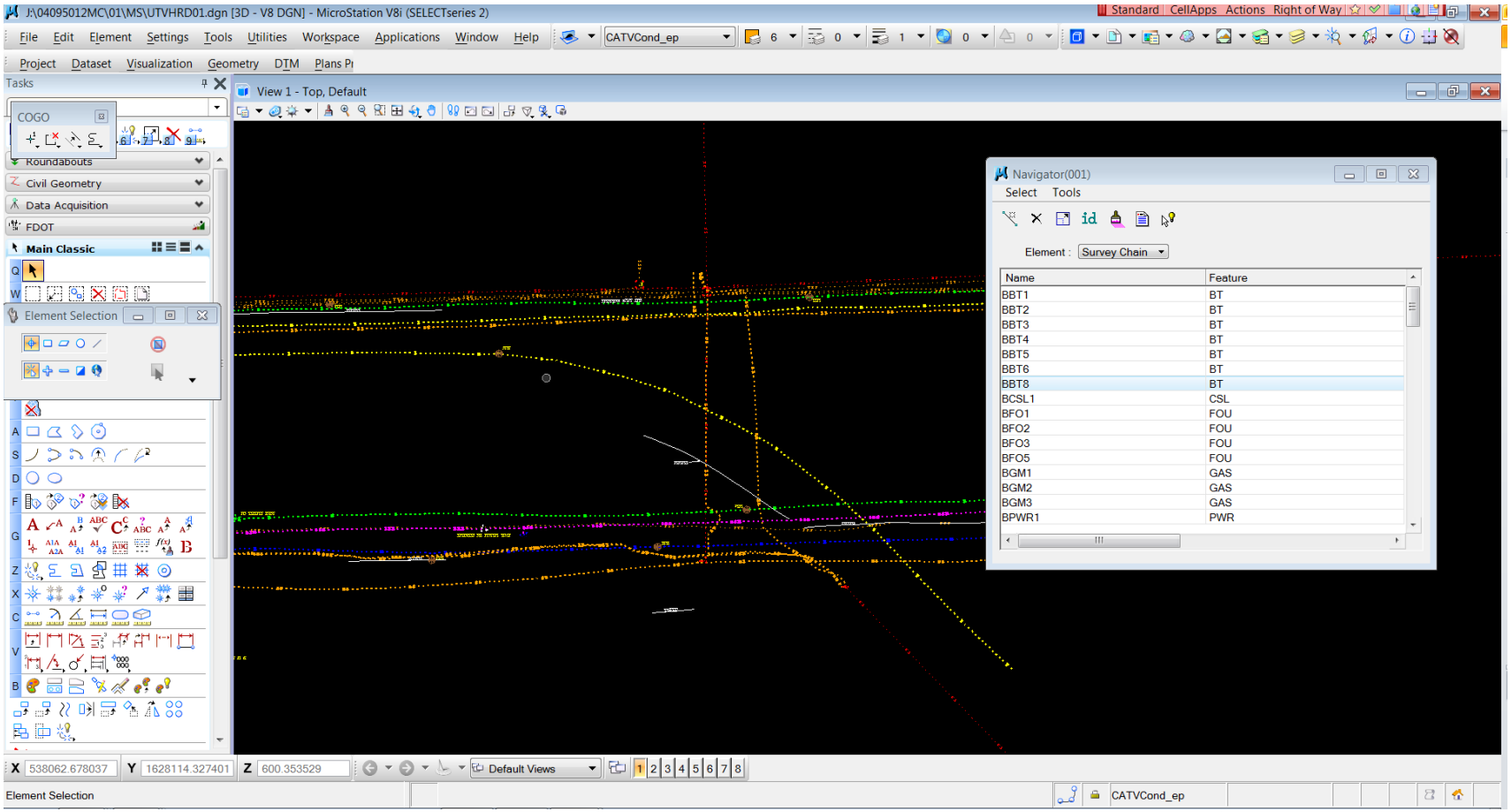
RADAR TOMOGRAPHY CONTRACT - TWO 1 - DEPTH COMPARISON TABLE

Point	TH#	Northing	Easting	Elevation	Depth/Cut (Feet)	Approximate Electronic Depth (Feet) EM Locator	Delta EM ED vs TH	Approximate Radar Depth (Feet) 3D RT (before correction)	Delta 3D RT ED vs TH	Abs Value of Delta EM ED vs TH	Abs Value of Delta 3D RT vs TH	Delta Comparison Best Value
CTH1	1	1628369.29	532098.29	42.11	4.93	N/A	N/A	4	0.93		0.93	N/A
CTH2	2	1628386.05	532100.87	42.34	4.80	N/A	N/A	4.2	0.60		0.6	N/A
CTH3	3	1628411.59	531864.74	43.61	3.50	N/A	N/A	3.7	-0.20		0.2	N/A
CTH4	4	1628218.19	531669.19	41.30	3.45	N/A	N/A	3.4	0.05		0.05	N/A
CTH5	5	1628396.69	531799.98	41.88	3.80	N/A	N/A	3.2	0.60		0.6	N/A
CTH6	6	1628442.94	531781.31	40.99	4.33	3.9	0.43	4.1	0.23	0.43	0.23	RT
CTH9	7	1628442.94	531781.31	40.99	4.07	3.9	0.17	4.1	-0.03	0.17	0.03	RT
CTH7	8	1628571.00	531490.66	42.30	2.41	1.5	0.91	2.2	0.21	0.91	0.21	RT
CTH8	9	1628571.77	531491.04	42.41	1.99	2	-0.01	2.4	-0.41	0.01	0.41	EM
DTH1	10	1628723.14	531556.16	39.14	2.06	3.8	-1.74	N/A	N/A	1.74		N/A
DTH6	11	1628705.16	531600.46	37.91	2.71	3.8	-1.09	2.7	0.01	1.09	0.01	RT
DTH7	12	1628649.89	531727.05	37.46	2.60	N/A	N/A	2.7	-0.10			N/A
DTH9	13	1628614.14	531815.27	38.13	2.97	N/A	N/A	2.5	0.47		0.47	N/A
DTH12	14	1628551.47	532022.08	38.44	2.93	N/A	N/A	N/A	N/A			N/A
DTH13	15	1628554.73	532022.40	38.38	3.76	3.5	0.26	2.5	1.26	0.26	1.26	EM
DTH10	16	1628541.01	531830.64	39.86	4.49	3.3	1.19	4.2	0.29	1.19	0.29	RT
DTH14	17	1628409.50	532005.49	43.73	4.27	4.5	-0.23	3.6	0.67	0.23	0.67	EM
DTH15	18	1628423.68	531926.16	43.76	3.46	4.5	-1.04	3.1	0.36	1.04	0.36	RT
DTH17	19	1628364.76	531812.38	42.35	3.81	N/A	N/A	3.6	0.21			N/A
DTH20	20	1628447.99	531797.27	42.36	8.17	12	-3.83	7.6	0.57	3.83	0.57	RT
DTH18	21	1628279.20	531697.03	40.71	1.60	N/A	N/A	1.2	0.40			N/A
DTH16	22	1628423.61	531898.69	43.66	4.29	N/A	N/A	3.9	0.39			N/A
EWM6	23	1628405.61	532004.13	43.65	6.05	N/A	N/A	5.3	0.75			N/A
ERW2	24	1628421.28	531898.45	43.61	9.50	9.5	0.00	N/A	N/A			N/A
ECSH1	25	1628618.75	531815.63	38.13	2.40	3.1	-0.70	2.4	0.00	0.7	0	RT
GCSH8	26	1628063.85	536485.35	53.33	2.50	2.7	-0.20	4.8	-2.30	0.2	2.3	EM
GCSH9	27	1628029.98	536619.59	53.85	6.00	N/A	N/A	5.1	0.90			N/A
GUNK2	28	1628235.93	536511.90	53.66	3.70	4.8	-1.10	2.8	0.90	1.1	0.9	RT
GCSH7	29	1628160.62	536670.79	55.88	3.90	5	-1.10	3.2	0.70	1.1	0.7	RT
GCSH10	30	1628026.74	536760.81	57.84	4.45	4.50	-0.05	N/A	N/A			N/A
GCSH12	31	1628024.20	536808.86	58.61	2.90	N/A	N/A	2.2	0.70			N/A
GCSH6	32	1628161.12	536808.72	57.30	3.10	3.5	-0.40	2.1	1.00	0.4	1	EM
GCSH5	33	1628162.52	536827.70	57.35	2.15	N/A	N/A	1.6	0.55			N/A
GCSH16	34	1627972.71	537036.84	57.47	3.55	4	-0.45	2.7	0.85	0.45	0.85	EM
GCSH13	35	1628009.67	537034.38	60.72	5.60	6.2	-0.60	3.2	2.40	0.6	2.4	EM
GCSH20	36	1628005.68	537314.11	61.87	4.55	N/A	N/A	3	1.55			N/A
GCSH14	37	1628016.38	537081.49	61.28	6.00	N/A	N/A	4	2.00			N/A
GCSH4	38	1628142.24	537107.00	59.18	2.35	3.5	-1.15	1.6	0.75	1.15	0.75	RT
GUNK17	39	1628152.80	537170.47	59.94	4.10	N/A	N/A	2.1	2.00			N/A

Export and Preparation of 2D and 3D DGN



Export and Preparation of 2D and 3D DGN



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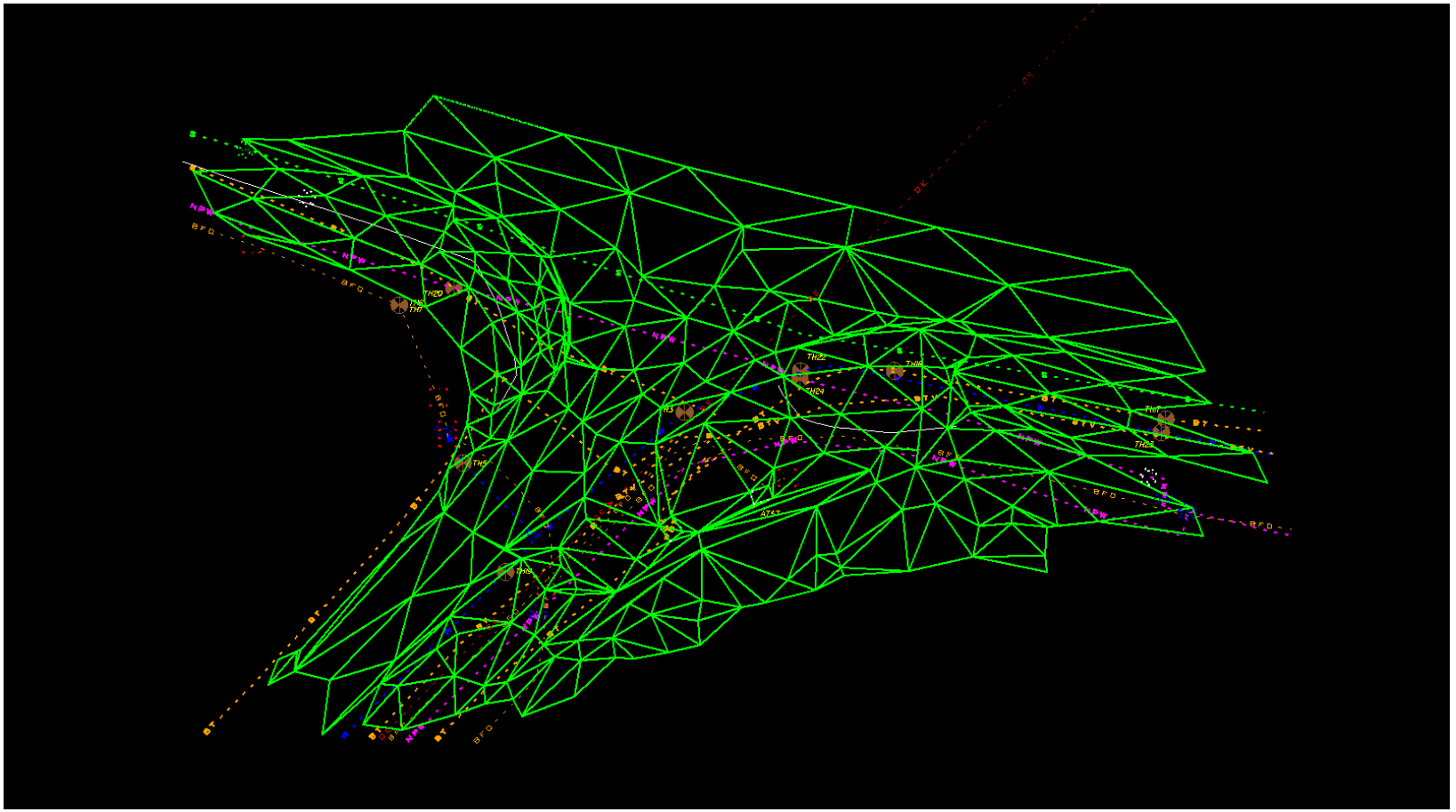
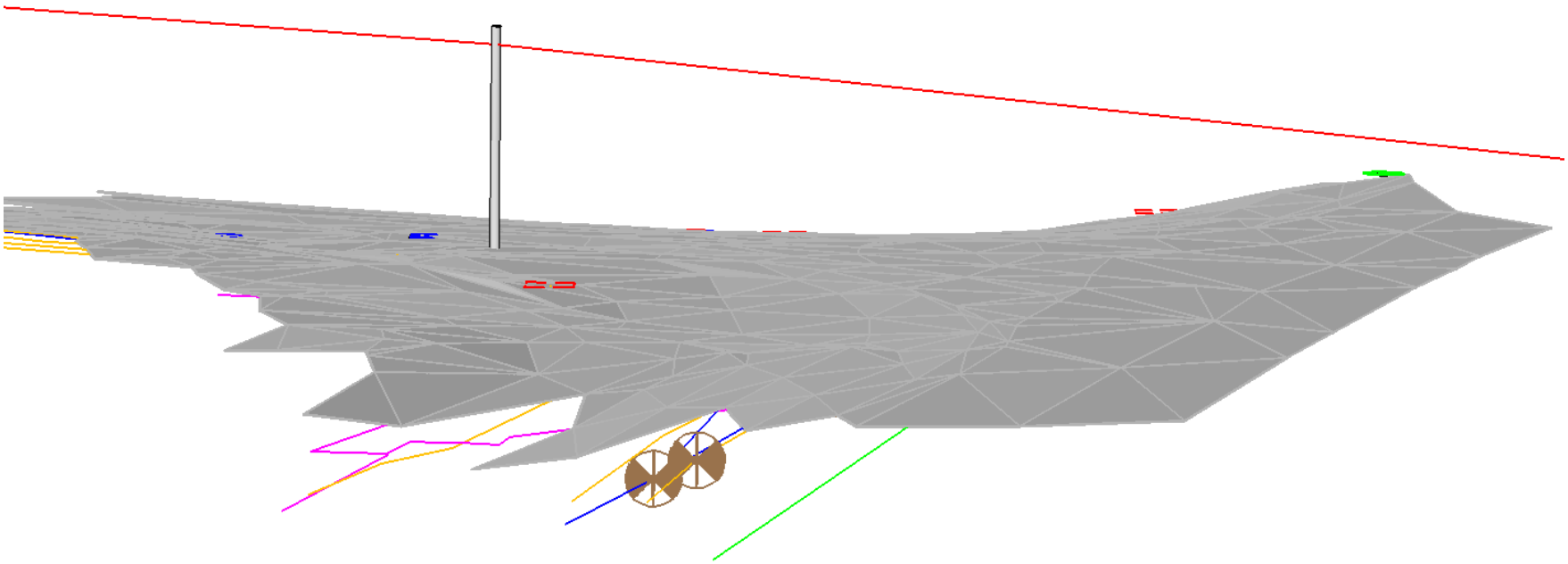
Export and Preparation of 2D and 3D DGN

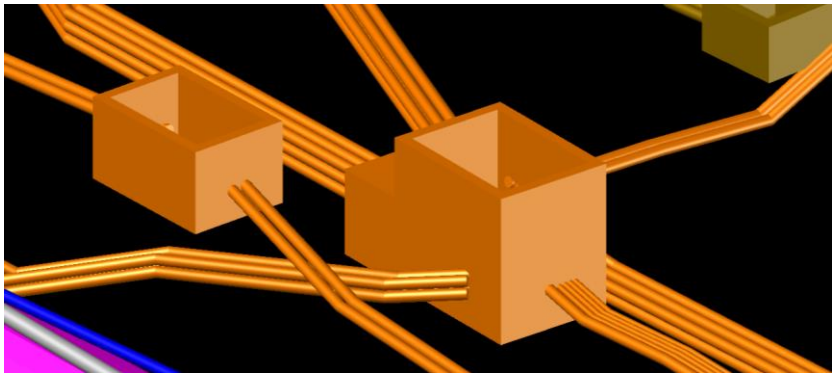


UTVHRD01.dgn



3D Utility Information:

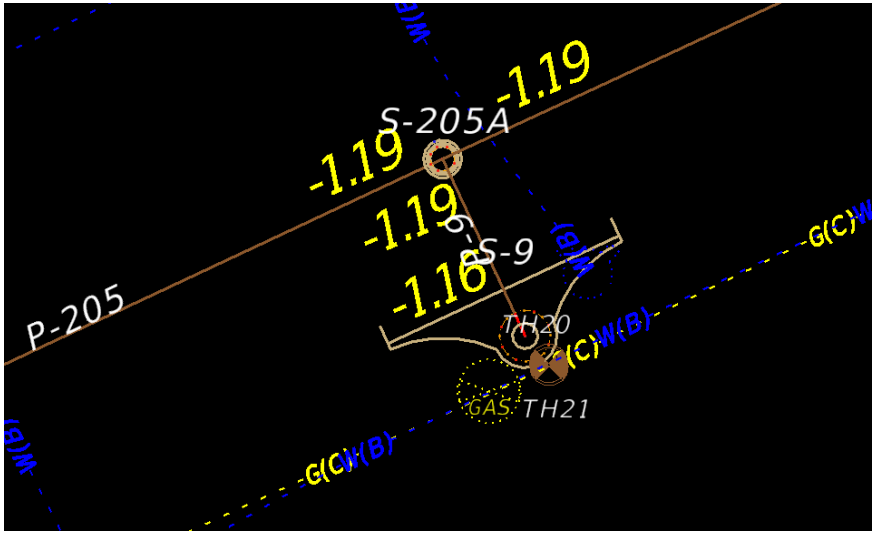
- Continuous 3D representation throughout the limits
- Cross sections with utility elevations (vs. interpolation between known points/THs)
- Enhanced conflict analysis
- Potential reduction of THs

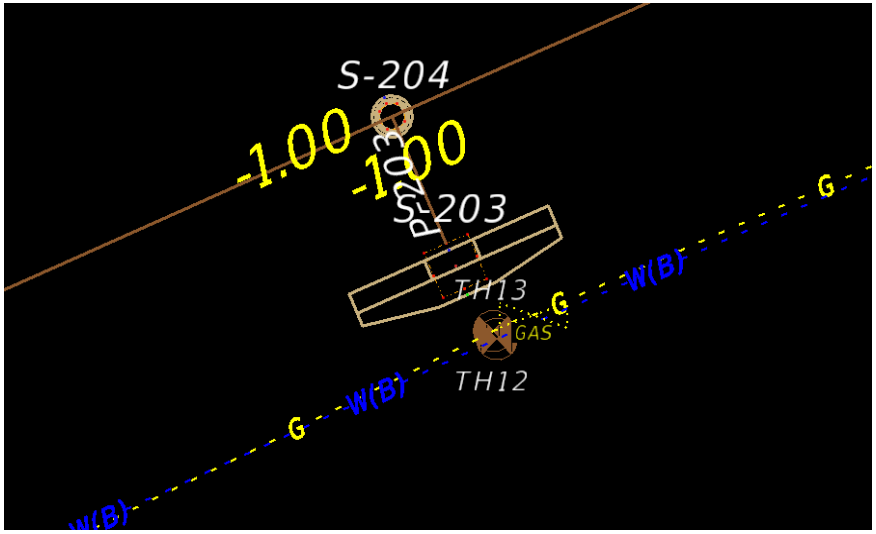


Elevations (Z) based on advanced geophysics, data interpretation and visual verification

Utility information used for roadway design

- 2-Dimensional utility information (QL D, C and B) added to design file
- Conflict analysis in X,Y (*Phase I*) and then Z (*Phase II*) based on utility information





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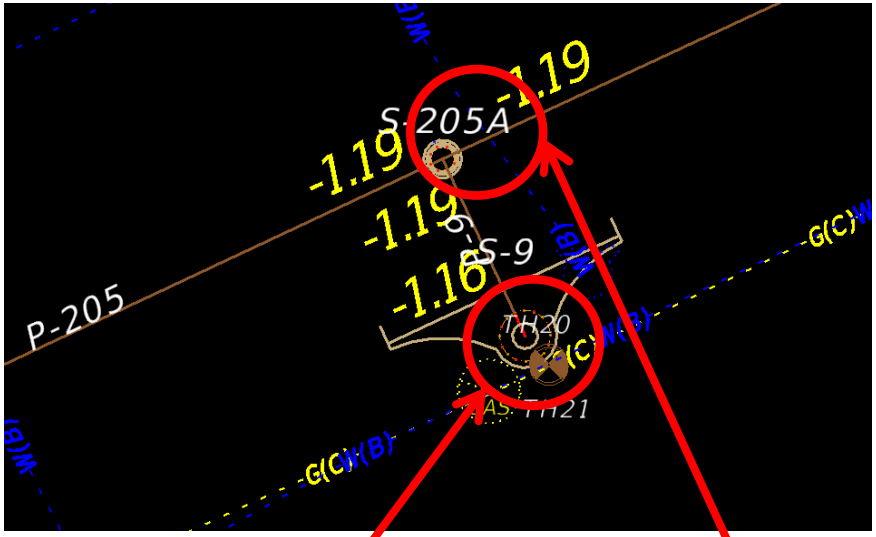
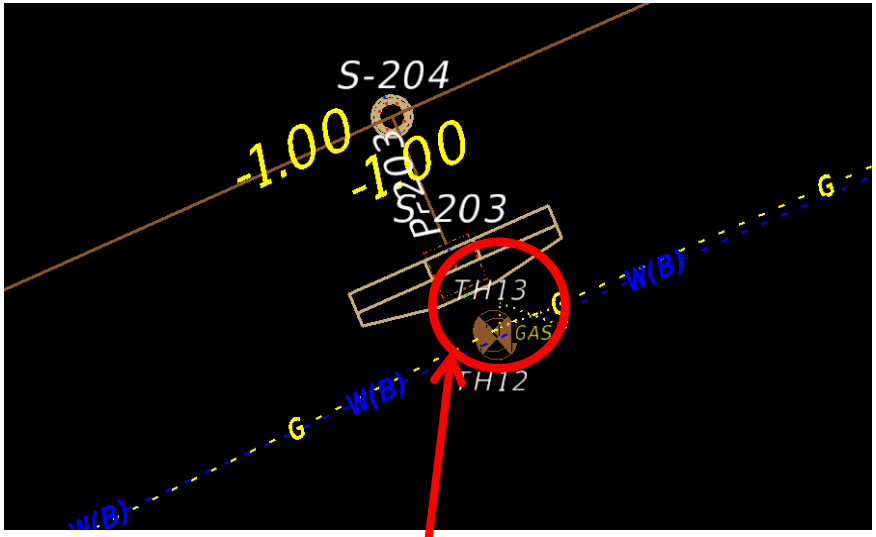


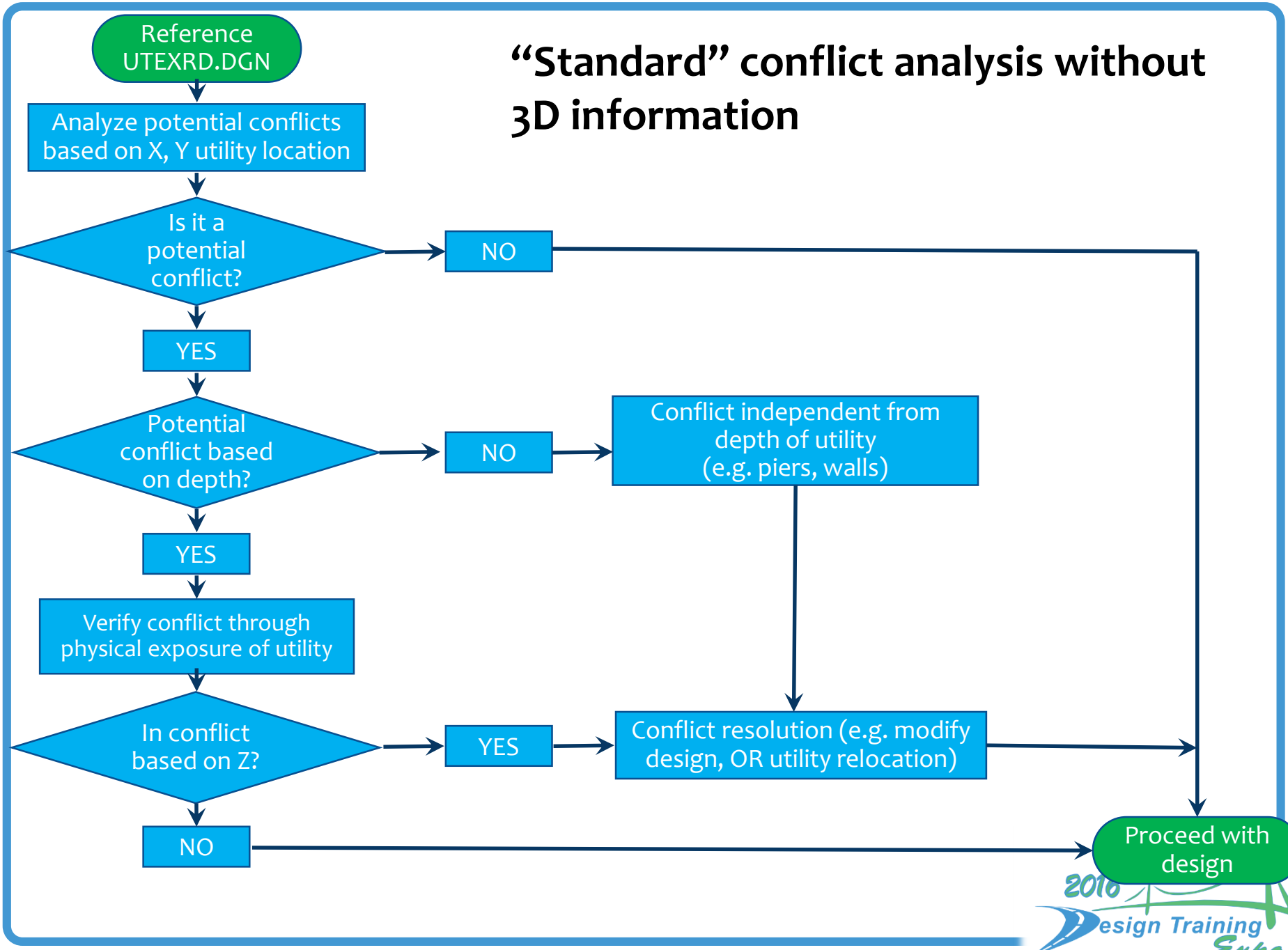
X,Y conflict

Z conflict?

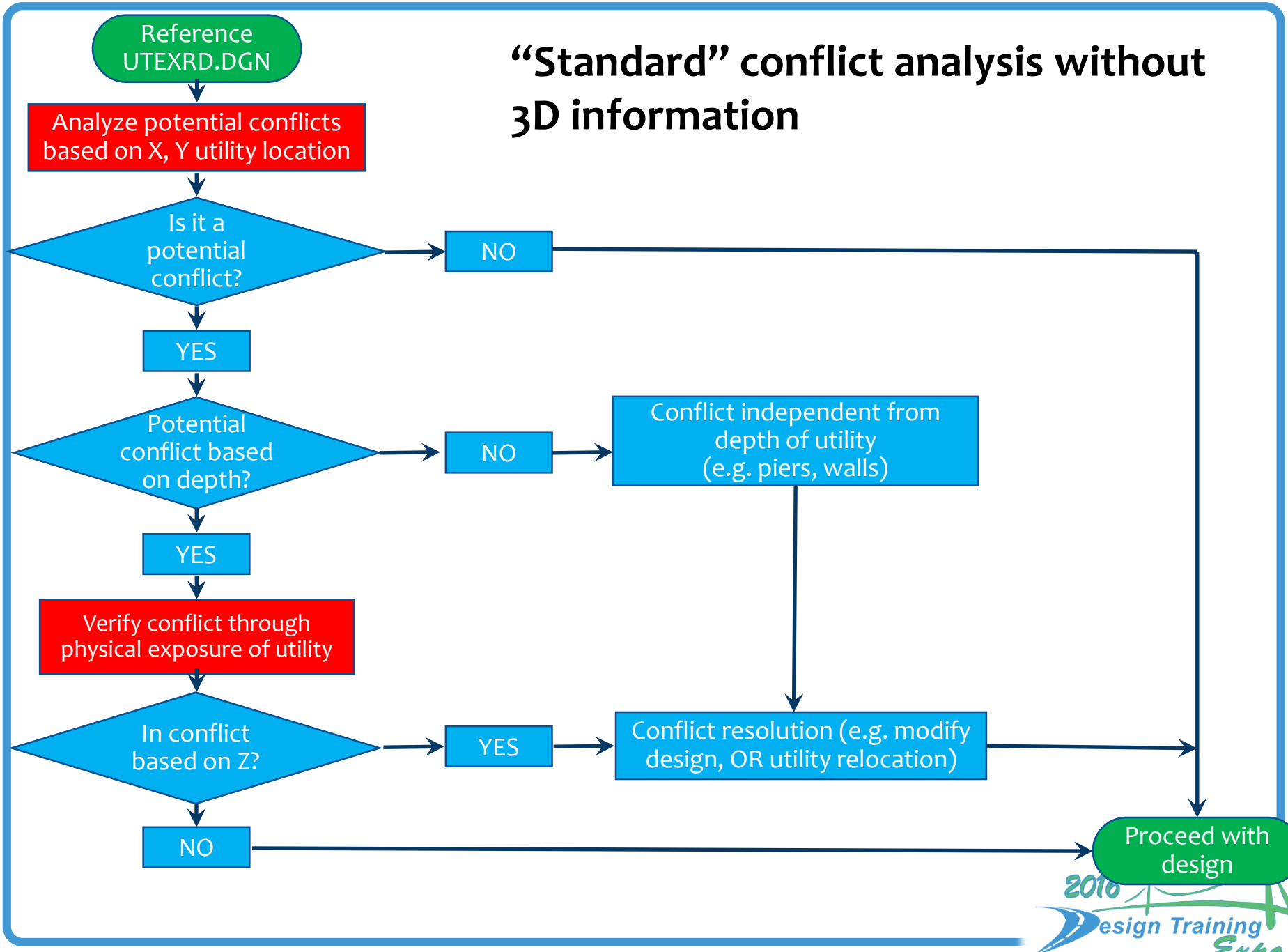


No X,Y conflict

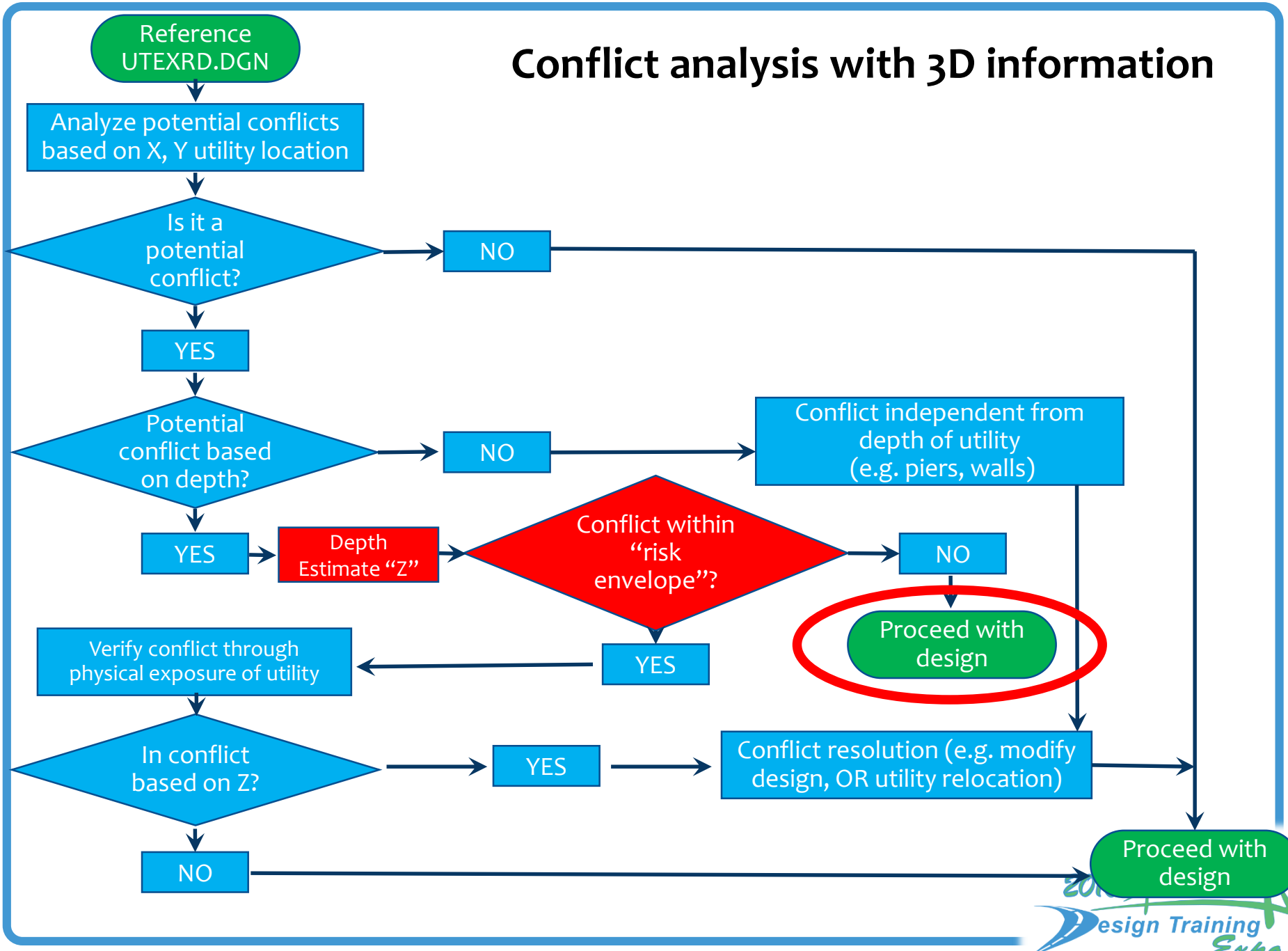
"Standard" conflict analysis without 3D information



"Standard" conflict analysis without 3D information

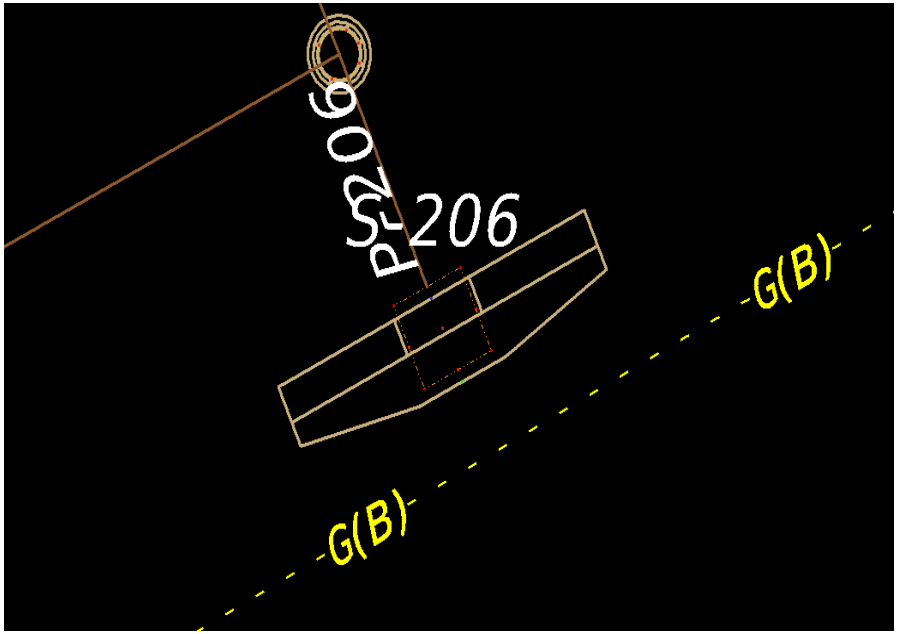


Conflict analysis with 3D information

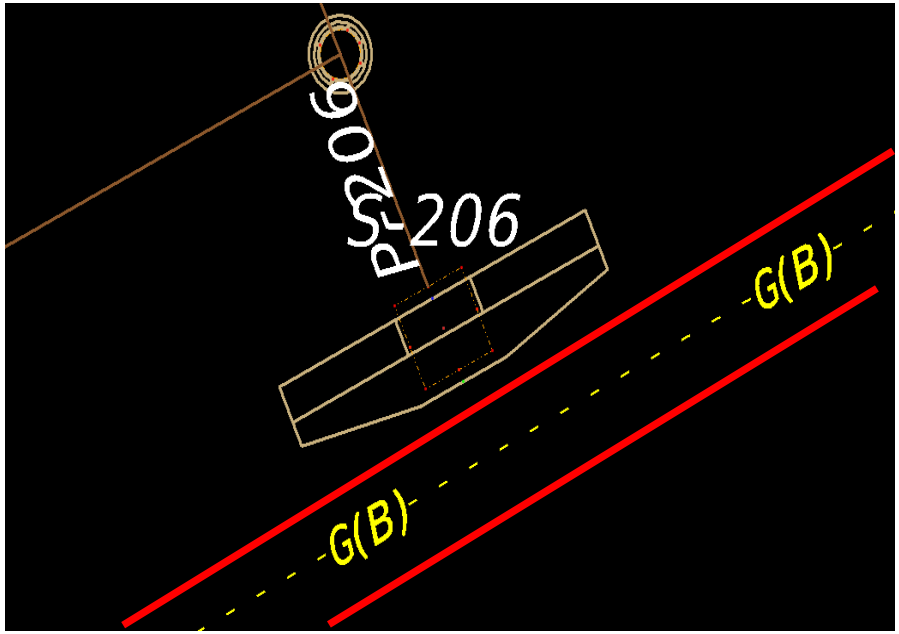


Conflict analysis and “Risk Envelope”

Gas line represented in 2D



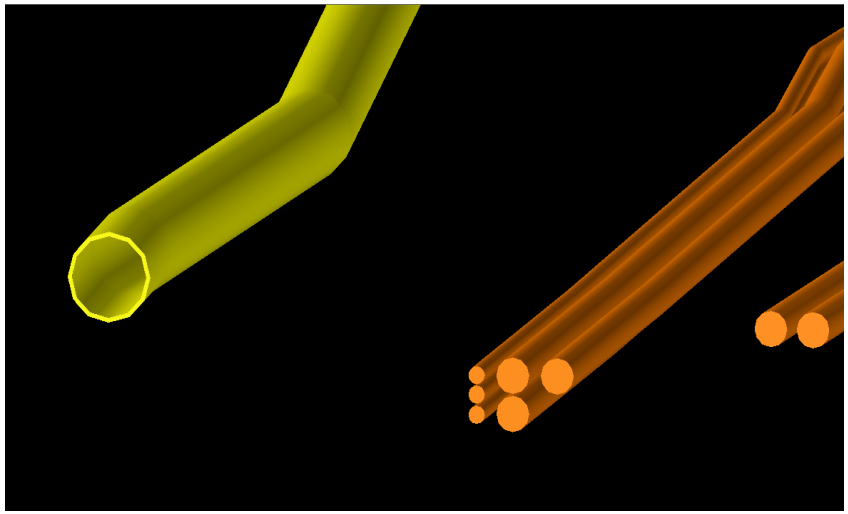
“Risk Envelope” in 2D



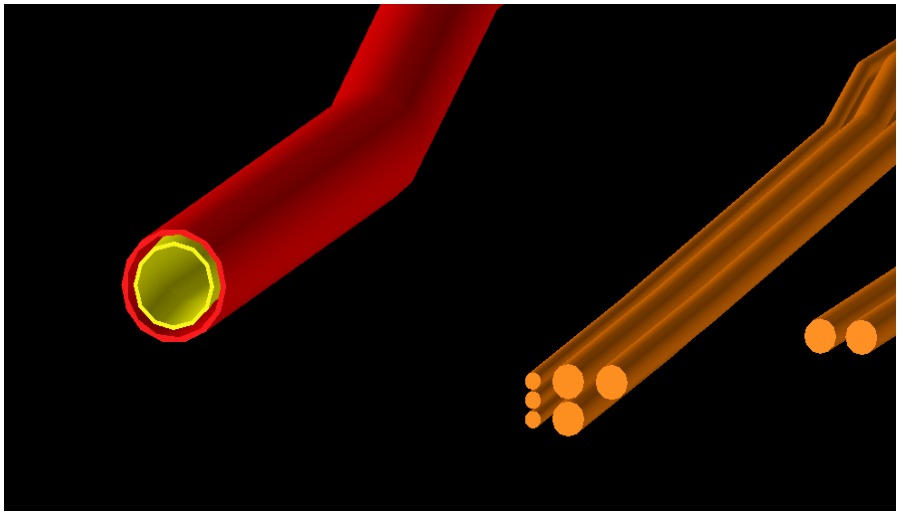
Professional judgment and source of utility information must be documented throughout the process

Estimated “Z” information and “Risk Envelope”

Gas line represented in 3D



“Risk Envelope” in 3D



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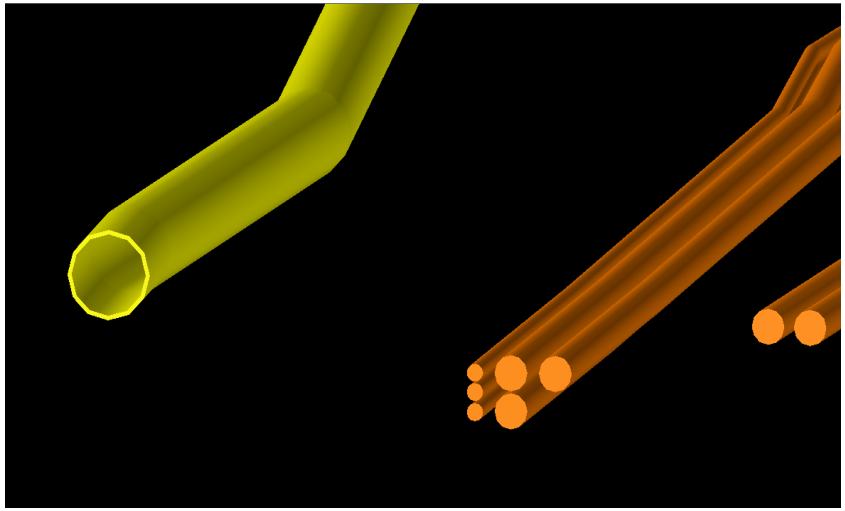
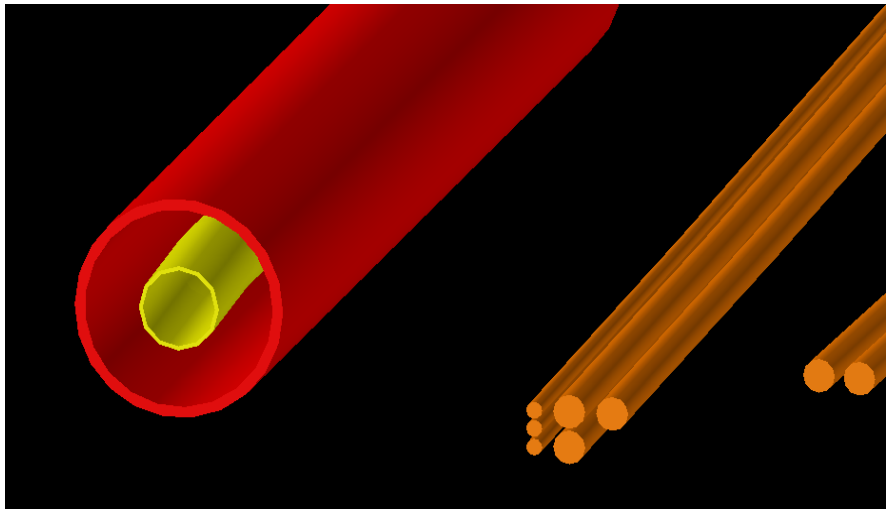


“Risk Envelope” in 3D



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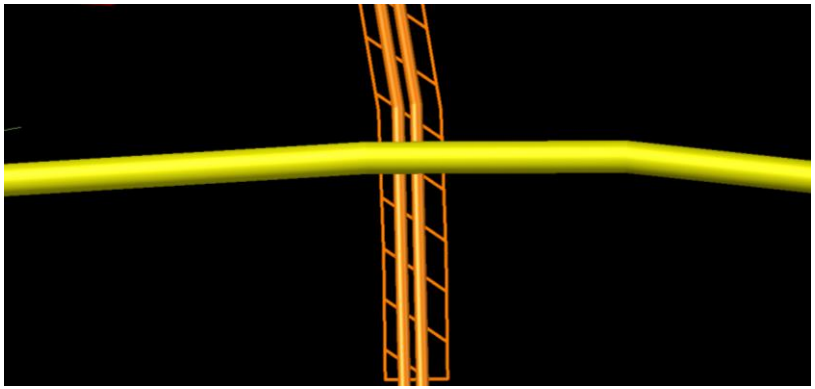
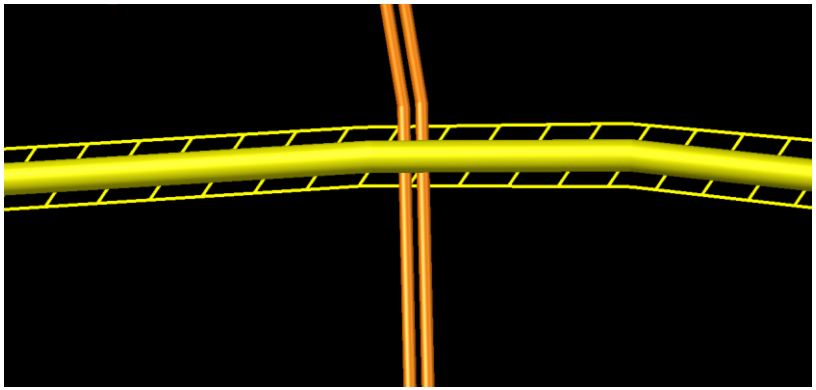
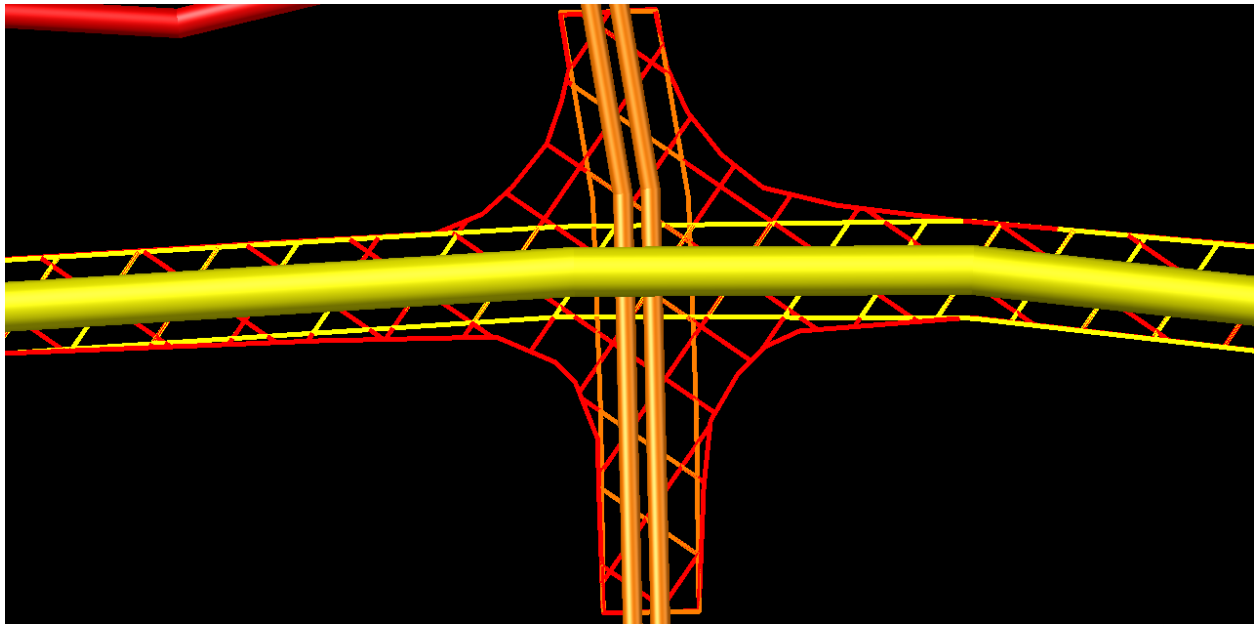


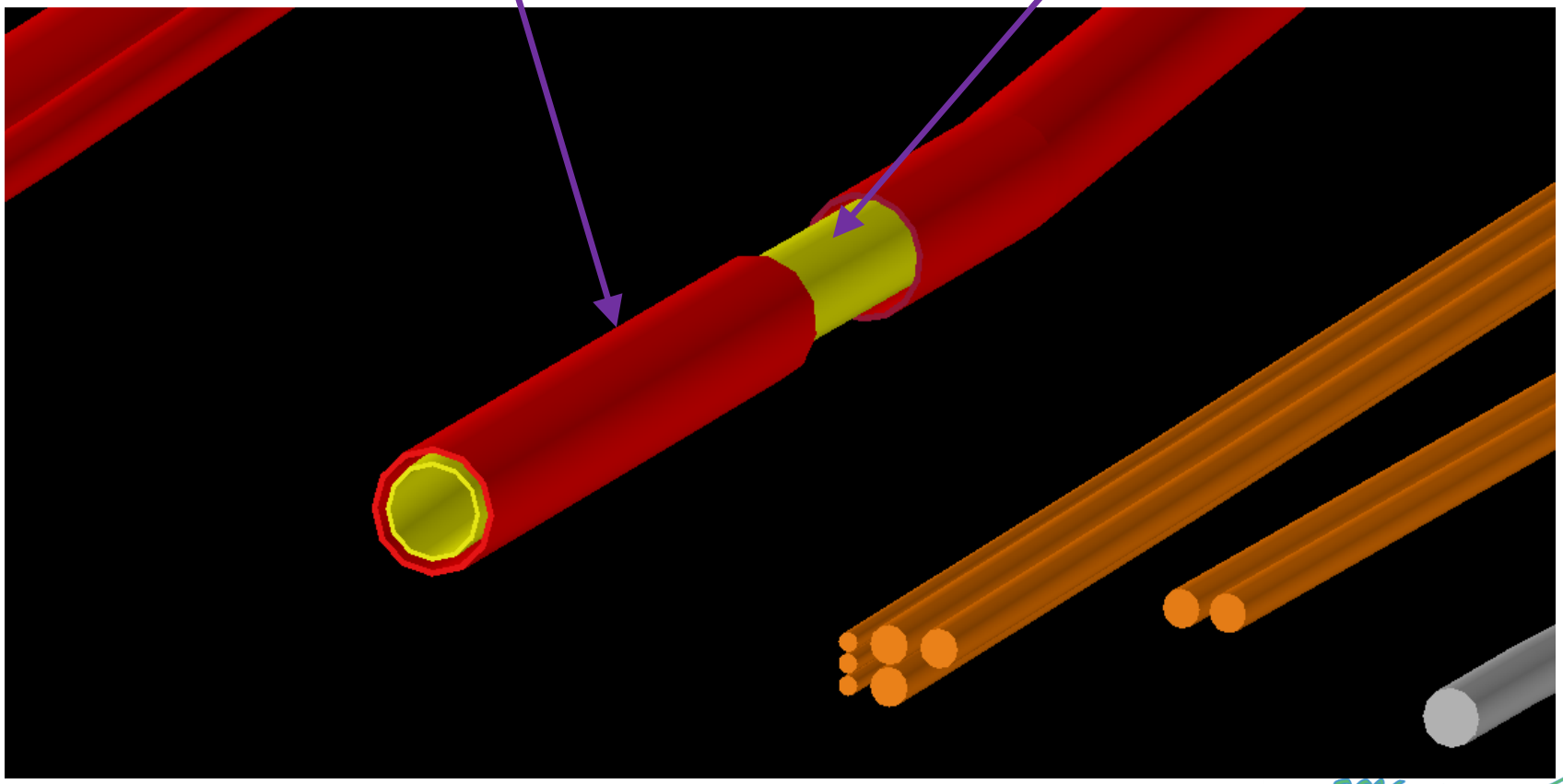




Estimated “Z” information and “Risk Envelope”

Quality Level B with depth qualifiers / “Risk Envelope”

Quality Level A at critical locations



3D Utility Information for Modeling: Possible Solutions

"Mock 3D File"

3D File with Limited Geophysics

3D File with RT/Advanced Geophysics

3D Utility Information for Modeling: Possible Solutions

"Mock 3D File"

- Conventional designating
- Build 3D Utility info based on ARBITRARY depths
- Perform THs at ALL potential conflict locations
- Adjust 3D utility info based on THs
- Benefits: visual aid / "3D" representation of utilities

3D Utility Information for Modeling: Possible Solutions

"3D File with Limited Geophysics"

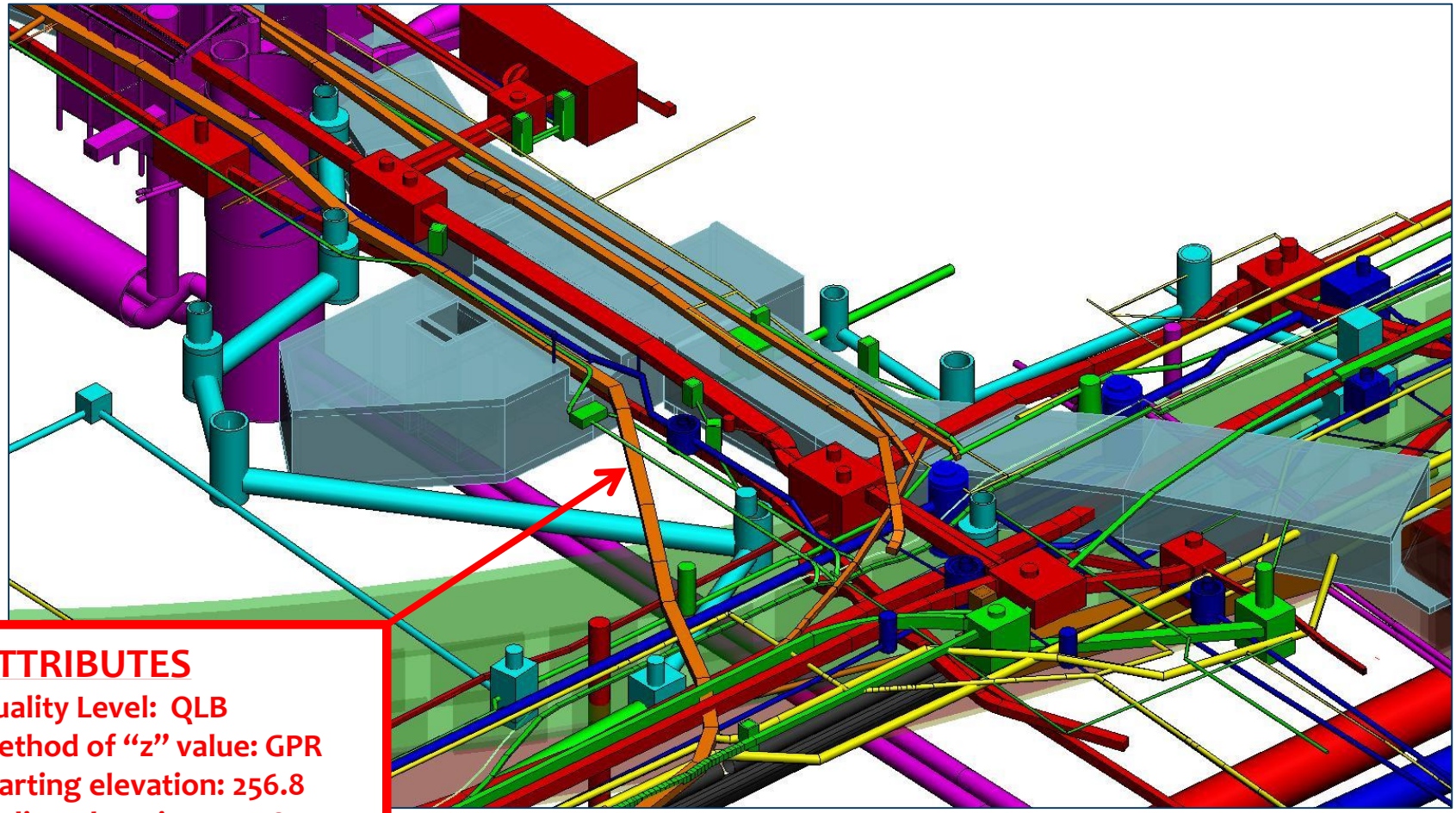
- Conventional designating + obtain electronic depth estimates (EDE) from pipe/cable locators and GPR in real time
- Obtain vertical data at all access points
- Build 3D Utility info based on limited depth information
- Perform THs at MOST potential conflict locations
- Adjust 3D utility info based on THs
- Benefit: fairly accurate 3D model; some savings on THs

3D Utility Information for Modeling: Possible Solutions

"3D File with RT/Advanced Geophysics"

- Conventional designating + obtain electronic depth estimates (EDE) from pipe/cable locators and GPR in real time
- Full RT scanning and processing
- Obtain vertical data at all access points
- Build 3D Utility info based on calibrated depth information
- Perform THs at SOME potential conflict locations
- Adjust 3D utility info based on THs
- Benefit: more accurate 3D model; savings on THs

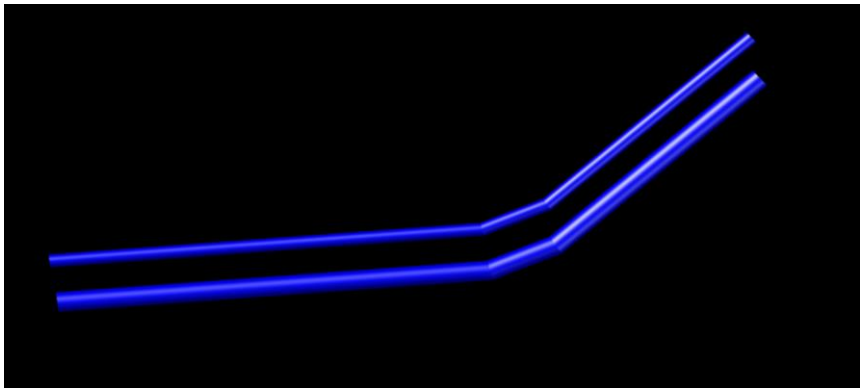
Document ALL Utility Information and Sources:

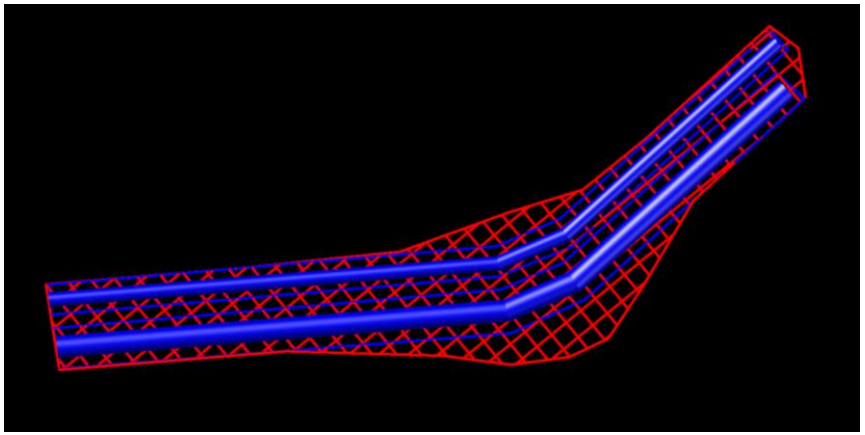


ATTRIBUTES

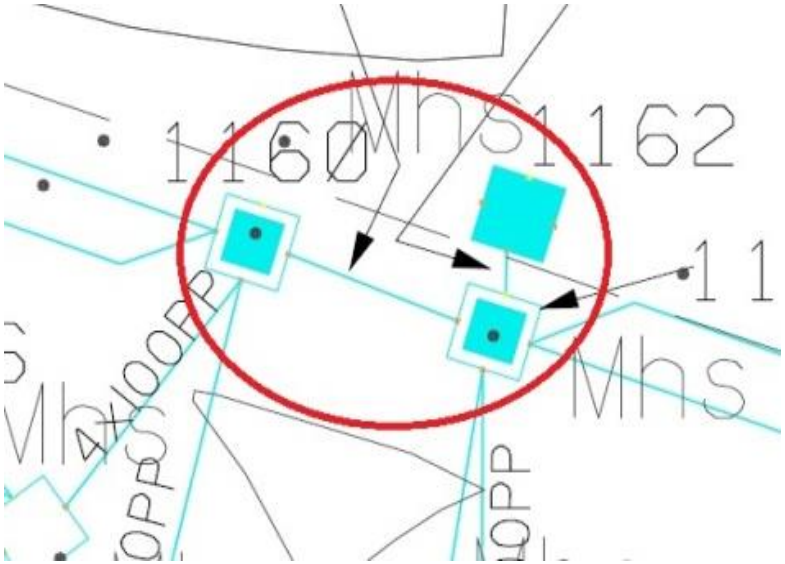
Quality Level: QLB
Method of "z" value: GPR
Starting elevation: 256.8
Ending elevation: 255.8
Size: 8"
Material: Metal within Plastic
Owner: ATT

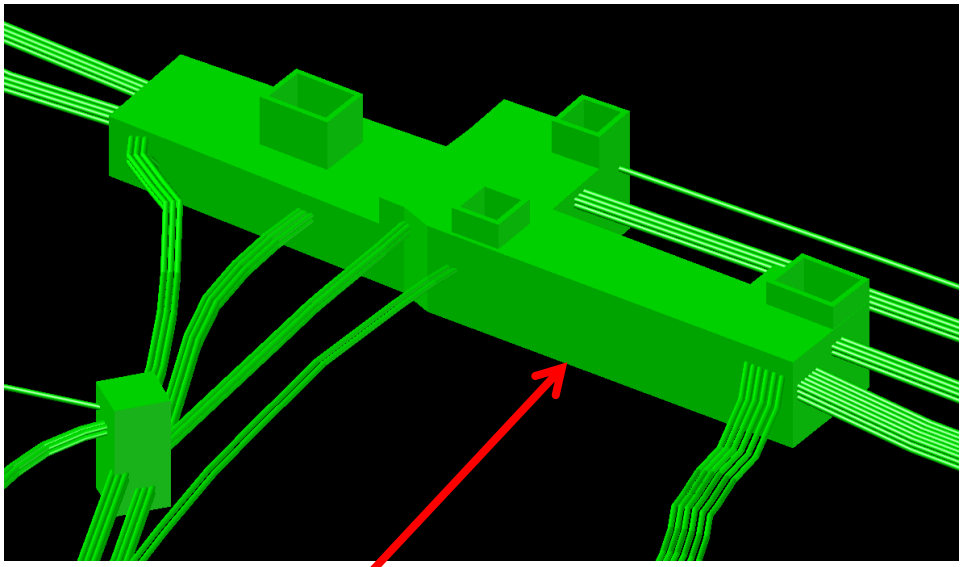
Document ALL Utility Information and Sources:





Document ALL Utility Information and Sources:





43ft long underground vault

Thank you !

Gary R. Roche, PSM (FDOT)
Carlo Pilia (Cardno)